transferred from said cache memory to said tone generator means.

[Claim 3]

A musical tone reproducing apparatus as claimed in claim 2, wherein the tone color changing command specifies the tone color parameter to a leading address of the tone color parameter to be changed in said general-purpose storage means.

[Claim 4]

A portable terminal apparatus having a musical tone reproducing apparatus as claimed in claim 2 or 3, wherein said system control means carries out a portable terminal function process as a main process.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a musical tone reproducing apparatus which is capable of changing tone color and is applicable to a portable terminal apparatus.

[0002]

[Prior Art]

Conventional musical tone reproducing apparatuses include ones that generate musical tones using hardware. Such a musical tone reproducing apparatus is constructed such that the tone color of reproduced musical tones can be changed.

An example of the construction of such a musical tone reproducing apparatus is shown in FIG. 10, and a description will now be given of the changing of the tone color. In FIG. 10, a CPU (central processing unit) 110 reads sequence data such as MIDI (musical instrument digital interface) data or SMAF (synthetic music mobile application format) data out from a RAM (random access memory) 111, and supplies the sequence data to a tone generator hardware section 115. The tone generator

hardware section 115 reproduces the supplied sequence data, and accordingly outputs musical tone signals to a speaker 134. The tone generator hardware section 115 is comprised of a tone color parameter storage region 130, and a data processing section 133 that carries out a musical tone reproducing process. The tone color parameter storage region 130 is comprised of registers or regions reserved in the RAM (Random Access Memory).

[0003]

In the musical tone reproducing apparatus constructed as above, when changing the tone color of a musical tone to be reproduced, the CPU 110 gives a tone color changing command to the tone color parameter storage region 130, and also reads a tone color parameter for the tone color to be changed to out from the RAM 111, and writes the tone color parameter into the tone color parameter storage region 130. Once musical tone reproduction timing been has reached, the data processing section 133 reads out the changed tone color parameter from the tone color parameter storage region 130, and carries out musical tone reproduction with a tone color changed using the tone color parameter. Note that much sequence data and a plurality of tone color parameters (a tone color parameter group) can be stored in the RAM 111.

[0004]

[Problems to Be Solved by the Invention]

In such a conventional musical tone reproducing apparatus, when changing the tone color, the CPU 110 reads the tone color parameter for the tone color to be changed to out from the RAM 111 and transfers the tone color parameter to the tone generator hardware section 115 as described above. In this case, because the data bus width of the tone generator hardware section 115 is approximately 8 bits, the bit width of the RAM or registers constituting the tone color parameter storage

region 130, is also limited to being approximately 8 bits. However, one or more tone color parameters for one channel required when the data processing section 133 carries out the tone reproducing process for one channel are comprised of many bits, specifically several tens of bits. Consequently, with a RAM or registers having a bit width of 8 bits, it has been necessary for the one or more tone color parameters for one channel required when the data processing section 133 carries out the tone reproducing process for one channel to be read out divided into a plurality of times each of 8 bits. As a result, a problem has arisen that a long time is required to read out the tone color parameter from the tone color parameter storage region 130 and set the tone color parameter in the data processing section 133, and hence the processing time becomes long.

[0005]

If the processing time becomes long to set the tone color parameter in the data processing section 133, then a break may occur in sound generation. To resolve this, one can envisage increasing the operating speed of the RAM or registers constituting the tone color parameter storage region 130.

However, if the operating speed of the RAM or registers is increased, then the electric power consumption thereof increases, and hence a battery that is used to operate a portable terminal apparatus in which the musical tone reproducing apparatus is installed is used up quickly, thus leading to a critical defect. Moreover, for every tone color change, the CPU 110 must transfer the tone color parameter for the tone color to be changed to from the RAM 111 to the tone generator hardware section 115, and hence there has been a problem that the amount of data transfer between the tone generator hardware section 115 and the CPU 110 increases.

Furthermore, if the tone color parameter storage region 130 is comprised of registers exclusively for this purpose, then reading out from a freely chosen number of registers can be carried out simultaneously, but the tone color parameter storage region 130 becomes a region exclusively for tone color parameters, and hence a problem arises that if it is also used for general-purpose data having a width of 8 bits other than tone color parameters, then the efficiency of usage of the memory becomes poor. Moreover, if the tone color parameter storage region 130 is comprised of a RAM having a large bit width, then a tone color parameter having a large bit width can be read out at a time, but the tone color parameter storage region 130 becomes a region exclusively for tone color parameters, and hence a problem again arises that if it is also used for general-purpose data having a width of 8 bits other than tone color parameters, then the efficiency of usage of the memory becomes poor.

[0006]

It is thus an object of the present invention to provide a musical tone reproducing apparatus and a portable terminal apparatus having a musical tone reproducing apparatus, which can shorten the time taken for a tone color changing process even if tone color parameters are stored in a general-purpose storage means.

[0007]

[Means for Solving the Problems]

In order to attain the above mentioned objects, the musical tone reproducing apparatus of the present invention comprises, a general-purpose storage means in which can be registered at least a tone color parameter group comprising a freely chosen number of tone color parameters, a tone generator means for carrying out musical tone reproduction based on predetermined tone

color parameters, and a cache memory having a large output data width at which the tone color parameters are transferred to said tone generator means, wherein when changing a tone color set in said tone generator means, a tone color parameter for the tone color to be changed to is read out from the tone color parameter group stored in said general-purpose storage means and transferred to said cache memory, and the tone color parameters for the tone color to be changed to is transferred from said cache memory to said tone generator means.

[0008]

Preferably, in the musical tone reproducing apparatus of the present invention, by outputting a tone color changing command from a system control means for carrying out a process other than a musical tone reproducing process as a main process, the tone color parameter which is specified by said tone color changing command is read out from said general-purpose storage means and transferred to said cache memory, and the tone color parameter specified by the tone color changing command is transferred from said cache memory to said tone generator means.

Still preferably, in the musical tone reproducing apparatus of the present invention, the tone color changing command specifies the tone color parameter to a leading address of the tone color parameter to be changed in said general-purpose storage means.

[0009]

Next, in order to attain the above mentioned objects the portable terminal apparatus of the present invention is a portable terminal apparatus having a musical tone reproducing apparatus wherein the system control means carries out a portable terminal function process as a main process.

[0010]

According to the present invention, because the musical tone reproducing apparatus has a general-purpose storage means which can register a tone color parameter group comprising a freely chosen number of tone color parameters, and a cache memory having a large output data width, during changing of tone color, a tone color parameter specified for changing that has have been read out from the general-purpose storage means may be transferred into the cache memory. In this case, because the tone color parameter group comprising a freely chosen number of tone color parameters has been registered in the general-purpose storage means, the need to transfer a tone color parameter from a system control section to the general-purpose storage means each time a tone color is to be changed can be removed as much as possible. Moreover, because the output bit width of the cache memory has been made to be large, the tone color parameter can be set into the tone generator means instantaneously. Consequently, even though the tone color parameters are stored in advance in the general-purpose storage means, the time taken for the tone color changing process can be shortened, and hence the occurrence of a break in sound generation during tone color changing can be prevented.

Moreover, because the tone color changing process is carried out by the system control means sending the leading address for the tone color parameter to be changed to in the general-purpose storage means, the amount of data transfer between the system control means and the musical tone reproducing apparatus can be reduced.

[0011]

[Embodiments]

FIG. 1 is a diagram showing an example of the construction of a preferred embodiment in which a portable terminal apparatus of the present invention

accommodating a musical tone reproducing apparatus of the present invention, is applied to a mobile phone.

A mobile phone 1 as shown in FIG. 1, generally has a retractable antenna 25 and can be connected to a base station 2 by a wireless communication line. The antenna 25 is connected to a communication section 13 having functions of modulation and demodulation. A CPU (central processing unit) 10 serves as a system controller that controls operations of various sections of the mobile phone 1 by executing telephone function programs, and is provided with a timer that shows elapsed time in the operations and generates a timer interrupt at predetermined time intervals. Moreover, the CPU 10 transfers sequence data by a predetermined amount at a time to a tone generator hardware section 15 during musical tone reproduction carried out, for example, upon receipt of an incoming call. A RAM 11 is a RAM (Random Access Memory) which has set therein, a storage area for sequence data downloaded from a downloading center or the like connected via the base station 2, a work area for the CPU 10, and so on. A ROM 12 is a ROM (Read Only Memory) which stores various programs executed by the CPU 10 including various telephone function programs for carrying out transmission and reception and programs for carrying out processes relating to musical tone reproduction and the like, and also various kinds of data such as preset sequence data.

[0012]

The communication section 13 demodulates a signal received by the antenna 25, and modulates a signal to be transmitted and supplies the modulated signal to the antenna 25. An incoming speech signal that has been demodulated by the communication section 13 is decoded by a speech processing section (coder/decoder) 14, and a speech signal inputted via a microphone 21 is subjected

to compression encoding by the speech processing section 14. The speech processing section 14, which subjects the speech to efficient compression encoding/decoding, is comprised, for example, of a coder/decoder of CELP (Code Excited LPC) type or ADPCM (Adaptive Differential PCM coding) type. The tone generator hardware section 15 is able to sound the incoming speech signal from the speech processing section 14 through an incoming speech speaker 22, and generate and output an incoming call melody and holding music by reproducing the sequence data. The incoming call melody is sounded from an incoming call speaker 23, and the holding music is mixed with the incoming speech signal and sounded from the incoming speech speaker 22.

[0013]

The format of the sequence data is a MIDI (Musical Instrument Digital Interface) format or a SMAF (Synthetic Music Mobile Application Format) format, which is convenient for data distribution. The tone generator hardware section 15 converts sequence data of such a format into control data of a format peculiar to a tone generator core built into the tone generator hardware section 15, and reproduces the converted data. Alternatively, the CPU 10 may convert the sequence data into control data of a format peculiar to the tone generator hardware section 15, store the converted data in the RAM 11, and read out the same from the RAM 11 and supply the same to the tone generator hardware section 15 during reproduction. The tone generator hardware section 15 has provided therein a general-purpose RAM in which is registered a tone color parameter group of a freely chosen number of tone color parameters, a cache memory having a large output bit width, and the tone generator core. The tone color parameter group registered in the general-purpose RAM is, for example, a tone color

parameter group according to General MIDI Standard. The cache memory stores tone color parameters for a tone color specified for each channel, and the tone generator core can read out a tone color parameter for one channel required for musical tone reproduction for that channel by accessing the cache memory only once or a few times.

[0014]

An interface (I/F) 16 is for downloading sequence data and so on from an external apparatus 20 such as a personal computer. An input section 17 serves as an input means comprised of dialing buttons "0" to "9" and various other buttons provided in the mobile phone 1. A display section 18 is comprised of a display device that displays telephone function menus and other displays according to operations of the buttons such as the dialing buttons. A vibrator 19 notifies a user of incoming calls by vibrating the main body of the mobile phone 1 instead of the incoming call melody when there is an incoming call. Moreover, the various function blocks transfer and receive data and so on via a bus 24.

[0015]

Next, an example of the construction of a musical tone reproducing apparatus of the mobile phone 1 of the embodiment of the present invention is shown in FIG. 2. Note, however, that in FIG. 2, the constructions of the incoming speech speaker 22 and the incoming call speaker 23 are omitted and are shown as a speaker 34. Moreover, data transfer between the CPU 10, the tone generator hardware section 15 and the RAM 11 is carried out via the bus 24, but the bus 24 is not shown in FIG. 2.

In the musical tone reproducing apparatus shown in FIG. 2, sequence data, and a tone color parameter group for various tone colors, are stored in the RAM 11. The tone color parameter group according to the General MIDI Standard or the like stored in the RAM 11 are transferred

to and registered in a tone generator memory 30 of the tone generator hardware section 15 under the control of the CPU 10. When registering a tone color parameter group in the tone generator memory 30, the CPU 10 gives a tone color parameter transmitting command a to the RAM 11, and the tone color parameters in the tone color parameter group to be registered are sequentially read out, and the read out tone color parameters b are supplied to the tone generator memory 30. At the same time, the CPU 10 gives a tone color parameter write (register tone color parameters into memory) command c to a controller 31. Upon receiving the tone color parameter write command c, the controller 31 generates addresses at which the tone color parameters b are to be written into the tone generator memory 30, and gives a tone color parameter writing command d to the tone generator memory 30. As a result, the tone color parameters a read out from the RAM 11 are written into a predetermined region of the tone generator memory 30. Moreover, a tone color parameter table in which is written the leading address for each tone color parameter registered in the tone generator memory 30 is stored by the CPU 10 in a work area of the RAM 11.

[0016]

When changing the tone color of a musical tone to be reproduced by the tone generator core 33, the CPU 10 gives a tone color changing command c to the controller 31. Having received the tone color changing command c, the controller 31 gives to the tone generator memory 30 a tone color parameter transmitting command d to transmit the specified tone color parameter to a cache memory 32. As a result, the tone generator memory 30 reads out the specified tone color parameters, and transmits the read out tone color parameter e to the cache memory 32. Moreover, although not shown in FIG. 2, during musical

tone reproduction, the tone generator core 33 gives a tone color parameter read request h to the cache memory 32 when reproduction timing for each event in the control data is reached, based on control data of a format peculiar to the tone generator core 33 of converted data supplied from the controller 31. Upon receiving the tone color parameter read request h, the cache memory 32 reads out a tone color parameter g, and sends the tone color parameter g to the tone generator core 33. Here, because the output bit width of the cache memory 32 is set at a bit width such that, for example, the tone color parameter g for one channel can be sent at a time, the tone color parameter can be set in the tone generator core 33 instantaneously. Through the above, the tone generator core 33 reproduces a musical tone of a tone color changed using the changed tone color parameters, and accordingly sends reproduction data i to the speaker 34, whereby the musical tone is sounded.

[0017]

Next, the operation of changing a tone color will be described in more detail, with reference to FIGS. 3 to 5. FIG. 3 is a diagram showing the detailed construction of the tone generator memory 30, the controller 31 and the cache memory 32 in the tone generator hardware section 15, FIG. 4 is a diagram showing an example of the data structure of a tone color parameter group registered in a tone generator RAM 30a constituting the tone generator memory 30, FIG. 5 is a diagram showing an example of the data structure of tone color parameters stored in a tone color cache memory 32a constituting the tone color cache memory 32.

In FIG. 3, a tone color parameter write command c is given by the CPU 10 to a tone generator memory address generating circuit 31a, and addresses at which the tone color parameters to be registered are to be written are

generated and given to an address input terminal of the tone generator RAM 30a. The tone generator RAM 30a is a general-purpose memory having an input bit width and an output bit width each of, for example, 8 bits. When the tone color parameter write command c is given by the CPU 10, a tone color parameter transmitting command a is also given by the CPU 10 to the RAM 11, and the tone color parameters b to be registered are read out. The read out tone color parameters b are given to a data input terminal of the tone generator RAM 30a. The tone color parameters b are then written into address positions sequentially given by the tone generator memory address generating circuit 31a. At this time, a tone color parameter group of a freely chosen number of tone color parameters, for example all of a group of tone color parameters according to the GM tone generator specification, can be written into the tone generator RAM 30a. Moreover, the leading address for the writing of each tone color parameter into the tone generator RAM 30a is given to the tone generator memory address generating circuit 31a as part of the tone color parameter write command c by the CPU 10, and a tone color parameter table in which is written the leading address for each tone color parameter is stored in the RAM 11.

[0018]

The data structure of a tone color parameter group registered in the tone generator RAM 30a is, for example, as shown in FIG. 4. In FIG. 4, the bit width of the tone generator RAM 30a is made to be 8 bits, a first tone color parameter is stored at address "1000h" (h indicates a hexadecimal number) to address "100Fh", a second tone color parameter is stored at address "1100h" to address "110Fh", and a third tone color parameter is stored at address "2FF0h" to address "2FFFh". Each tone color parameter is stored, for example, in a region of 16 lines

× 8 bits of consecutive addresses, and hence each time an incremented address is given by the tone generator memory address generating circuit 31a, a fragment of 8 bits maximum of a tone color parameter is written into the tone generator RAM 30a. In the example shown in FIG. 4, each tone color parameter is thus divided into 16 fragments each of a size not more than 8 bits, and is registered in the tone generator RAM 30a in the form of 16 fragments. Tone color parameters from the first tone color parameter to an $m^{th}$ tone color parameter (where m is a freely chosen integer) registered in the tone generator RAM 30a are taken as a tone color parameter group. The tone color parameters shown in FIG. 4 are tone color parameters for an FM tone generator. Each tone color parameter is comprised of parameters such as SR (sustain rate), ERB (reverb on/off), SUS (sustain level), RR (release rate), DR (decay rate), WS (waveform selection), and FB (feedback level).

A predetermined tone color parameter group is stored in a tone generator ROM 30b in advance, and the data structure thereof is made to be like the example of the data structure shown in FIG. 4.

[0019]

Moreover, when changing a tone color, a tone color changing command c outputted from the CPU 10 is applied to a register address generating circuit 31b. The specification of the tone color parameter for the tone color to be changed by the tone color changing command c is carried out by abbreviating the leading address in the tone generator RAM 30a and the channel number. The register address generating circuit 31b then rewrites a voice address for the channel in question in a voice address register in a control register 31c from the leading address and channel number for the tone color parameter specified by the tone color changing command c.

The voice address register is comprised of registers for the maximum number of simultaneously sounded channels, and the leading address for the tone color parameter set for each slot (channel) is written as a voice address into the register for that each slot. Which channel it is for which the corresponding voice address has been changed is then detected by a Voice Adr change detecting circuit 31d, and the slot number corresponding to that channel is sent to a cache transfer waiting queue register 31e. The cache transfer waiting queue register 31e serves as a register for creating a slot number queue for transferring the tone color parameters sequentially when the change in tone color is to be carried out over a plurality of channels at once, and has a FIFO (first in first out) construction. The leading slot number outputted from the cache transfer waiting queue register 31e is given to a slot number - voice address converting circuit 31f, and referring to the voice address register in the control register 31c, the slot number is converted into the voice address written in the register for the corresponding slot. As described above, this voice address is the leading address for the tone color parameter specified for the corresponding channel, and a tone color parameter transmitting command d containing the leading address is given by the slot number - voice address converting circuit 31f to the tone generator memory address generating circuit 31a.

[0020]

The tone generator memory address generating circuit 31a determines whether the leading address contained in the tone color parameter transmitting command d is within the address range of the tone generator RAM 30a or within the address range of the tone generator ROM 30b, and reads out the corresponding specified tone color parameter from the tone generator RAM 30a or the tone

generator ROM 30b. Here, the tone generator memory address generating circuit 31a reads out the entire tone color parameter for one channel, by incrementing the address starting with the leading address 15 times, for example. The read out specified tone color parameter e is given to a data input terminal of the tone color cache memory 32a via a selector 30c. Moreover, the leading slot number outputted from the cache transfer waiting queue register 31e is also given to a cache address generating circuit 32b as a tone color parameter receiving command f. The tone color cache memory 32a is made capable of storing tone color parameters for the maximum number of channels that can be simultaneously sounded, and the cache address generating circuit 32b generates a cache address corresponding to the given slot number, and gives this cache address to an address input terminal of the tone color cache memory 32a. As a result, the tone color parameter set for the slot number specified by the cache address in the tone color cache memory 32a is rewritten using the specified tone color parameter e sent from the selector 30c.

[0021]

Sequence data, on the other hand, is given to the control register 31c, where the sequence data is converted into control data of a format peculiar to the tone generator core 33, and once reproduction timing for each event in the control data has been reached, setting into the tone generator core 33 from the control register 31c is carried out. As a result, the tone generator core 33 progressively reproduces musical tones based on the sequence data; moreover, at this time the tone color parameter set for the channel for which the tone generator core 33 carries out reproduction is received from the tone color cache memory 32a. Specifically, when the reproduction timing for each event has been reached,

the tone generator core 33 gives the slot number corresponding to the channel for which reproduction is to be carried out to the cache address generating circuit 32b as a tone color parameter read request h. Upon receiving the tone color parameter read request h, the cache address generating circuit 32b generates the cache address of the position where the tone color parameter set for the slot number in question is stored, and gives this cache address to the tone color cache memory 32a. As a result, the tone color parameter set for that slot number is sent to the tone generator core 33, for example, at a time, and the tone generator core 33 carries out musical tone reproduction for the channel corresponding to the slot number in question using the sent tone color parameter.

[0022]

Here, an example of the data structure of the tone color parameters stored in the tone color cache memory 32a is shown in FIG. 5. As shown in FIG. 5, the output bit width of the tone color cache memory 32a is set at several tens of bits such that each tone color parameters for one channel comprised of parameters from a parameter SR to a parameter FB can be contained in one row, and has a number of rows equal to the maximum number of channels that can be simultaneously sounded by the tone generator core 33. Specifically, the tone color parameter for channel 1 is stored in the first row, the tone color parameter for channel 2 is stored in the second row, and so on up to the tone color parameter for channel N which is stored on the $N^{th}$ row. Because of the large output bit width (e.g. approximately 60 bits) as described above, a tone color parameter for one channel can be sent to the tone generator core 33 at a time. As a result, the tone color parameters can be sent to the tone generator core 33 instantaneously, and hence musical tone reproduction

can be carried out without a break in sound generation. Here, N is the maximum number of channels that can be simultaneously sounded minus one.

[0023]

Moreover, it is arranged such that when a tone color is being changed, until the transfer of the specified tone color parameters to the tone color cache memory 32a has been completed, key on mask is carried out so that the musical tone of the tone color after the change will be reproduced reliably. To this end, the Voice Adr change detecting circuit 31d gives information on the slot number corresponding to the channel for which the tone color to be outputted has been changed to a key on masking circuit 31g. The key on masking circuit 31g generates a key on mask signal for masking key on for the channel corresponding to the given slot number information, and sends this key on mask signal to the tone generator core 33. As a result, in the tone generator core 33, key on for that channel is masked, and musical tone reproduction is suspended. Once transfer of the specified tone color parameter to the tone color cache memory 32a has been completed, a transfer complete flag is set, and the key on masking circuit 31g is reset to the original state. As a result, the rewritten tone color parameter newly set for the slot number in question is sent to the tone generator core 33, and hence using the sent tone color parameter, the tone generator core 33 can carry out musical tone reproduction reliably with the changed tone color for the channel in question.

[0024]

Moreover, in the case that the tone generator core 33 is comprised of a PCM tone generator, various sampling waveforms can be stored in the tone generator ROM 30b and the tone generator RAM 30a. During musical tone reproduction, a waveform address for the specified tone

color is given by the tone generator core 33 to the tone generator memory address generating circuit 31a. The tone generator memory address generating circuit 31a determines whether the given waveform address is within the address range of the tone generator RAM 30a or within the address range of the tone generator ROM 30b, and reads out the corresponding specified waveform data from the tone generator RAM 30a or the tone generator ROM 30b. The read out waveform data is given to the tone generator core 33 via the selector 30c, and the tone generator core 33 carries out musical tone reproduction with the specified tone color using this waveform data.

The tone generator RAM 30a is thus made to be a general-purpose memory in which can be stored not only tone color parameters but also other data.

[0025]

Next, a flowchart of the reproduction process carried out by the tone generator hardware section 15 of the musical tone reproducing apparatus of the present invention is shown in FIG. 6.

In the case that a mobile phone, in which a musical tone reproducing apparatus is applied, is set such that a melody informing of an incoming call is reproduced by the musical tone reproducing apparatus, an instruction for musical tone reproduction is issued upon receipt of an incoming call, whereby the reproduction process shown in FIG. 6 is started. In step S1, an initialization process is carried out in which the tone generator hardware section 15 is initialized, for example various registers are reset or set to default values. Then, a tone color parameter memory registration process of step S2, a tone color changing process of step S3, and a tone data process of step s4 are carried out in parallel. The processes of these steps S2 to S3 are carried out repeatedly until the sequence data comes to an end or a

stop instruction is issued, whereby reproduced musical tones are outputted based on the sequence data.

[0026]

Next, the processes of steps S2 to S3 will be described with reference to FIGS. 7 to 9.

First, a flowchart of the tone color parameter memory registration process is shown in FIG. 7.

After the instruction to start musical tone reproduction has been issued and the initialization process has been carried out, upon a user operating buttons of the input section 17 to select tone color parameter memory registration, the tone color parameter memory registration process shown in FIG. 7 is started. In step S10, it is determined whether or not there has been a registration request from the CPU 10. Here, in the case that a tone color parameter write command c has been given to the tone generator hardware section 15 and a tone color parameter transmitting command a has been given to the RAM 11 by the CPU 10, the answer is determined to be "YES" and the process proceeds to step S11, where in step S11 tone color parameters read out from the RAM 11 are registered in the tone generator RAM 30a of the tone generator memory 30. Once the registration has been completed, the tone color parameter memory registration process ends, and the process returns. Moreover, in the case that it is determined in step S10 that there has not been a registration request from the CPU 10, again the tone color parameter memory registration process ends, and the process returns.

[0027]

Next, a flowchart of the tone color changing process is shown in FIG. 8.

In FIG. 8, after the instruction to start musical tone reproduction has been issued and the initialization process has been carried out, upon the tone color

changing process being started through a tone color change message or the like embedded in the sequence data, in step S20 it is determined whether or not a tone color changing command has been received from the CPU 10. Here, in the case that the CPU 10 has given a tone color changing command c to the controller 31 of the tone generator hardware section 15, the answer is determined to be "YES", and the process proceeds to step S21 and step S22. In step S21, the specified tone color parameter is read out from the tone generator RAM 30a or the tone generator ROM 30b, and is transmitted to the tone color cache memory 32a. Moreover, in step S22, which is carried out in parallel with step S21, the transmitted tone color parameter is received by the tone color cache memory 32a, and the tone color parameter for the specified channel is rewritten. Once the processes of step S21 and step S22 have been completed, the tone color changing process ends, and the process returns. Moreover, in the case that it is determined in step S20 that a tone color changing command has not been received from the CPU 10, again the tone color changing process ends, and the process returns.

[0028]

Next, a flowchart of the tone data process of step is shown in FIG. 9.

After the instruction to start musical tone reproduction has been issued and the initialization process of the tone generator hardware section 15 has been carried out, when reproduction timing for each event in the control data been has reached, the control data is set into the tone generator core 33 by the controller 31. As a result, when the timing of reproduction of a musical tone has been reached, the tone data process is started. In step S30, it is then determined whether or not key on has been set in the tone generator core 33 and the

current state is key on. Here, in the case that key on has been set, the answer is determined to be "YES" and the process proceeds to step S31, where the tone generator core 33 reads out the tone color parameter for the channel for which reproduction is to be carried out from the tone color cache memory 32a. Next, in step S32, data processing is carried out in which musical tone reproduction is carried out based on the read out tone color parameter and the control data that has been set in the tone generator core. Then, in step S33, the reproduced musical tone data is outputted (sounded). Once the process of step S33 has been completed, the tone data process ends, and the process returns. Moreover, in the case that it is determined in step S30 that the current state is not key on, again the tone data process ends, and the process returns.

[0029]

In the above description, it is arranged such that a tone color parameter for one channel is sent to the tone generator core 33 with one access from the tone color cache memory 32a; however, the output bit width may be narrowed somewhat so that a tone color parameter for one channel is sent to the tone generator core 33 with a few accesses. Even in this case, there will be virtually no effect in terms of sound generation break due to the time taken for the process in question.

The musical tone reproducing apparatus of the present invention described above cannot only be applied to a mobile phone as described above as the portable terminal apparatus, but may also be applied to a portable information apparatus capable of outputting musical tones, a portable personal computer capable of outputting musical tones, and so on. In this case, the music contents data may be reproduced in synchronization with text and/or image contents.

[0030]

Moreover, the tone generator core 33 in the tone generator hardware section 15 may be comprised of a tone generator of frequency modulation type, i.e. an FM tone generator. Such an FM tone generator utilizes harmonics generated by frequency modulation for synthesis of musical tones, and is capable of generating waveforms having harmonic components containing non-harmonic tones with relatively simple circuitry. Such an FM tone generator is also capable of generating a wide variety of musical tones from synthesized tones simulating natural musical instruments to electronic bleeps. Such an FM tone generator employs oscillators called "operators" that equivalently oscillate sine waves, for example the FM tone generator may be comprised of a first operator and a second operator that are cascaded with each other. Moreover, such an FM tone generator may be constructed such that an output from an operator is itself fed back and inputted.

Furthermore, the tone generator type of the tone generator core 33 of the tone generator hardware section 15 is not limited to the FM tone generator type, but rather may be a waveform memory tone generator (PCM tone generator or ADPCM tone generator) type, a physical model tone generator type, and so forth. In terms of the construction of the tone generator, a hardware tone generator using a DSP or the like may be employed.

[0031]

[Effect of the Invention]

As described in detail above, because the musical tone reproducing apparatus has a general-purpose storage means which can register a tone color parameter group comprising a freely chosen number of tone color parameters, and a cache memory having a large output data width, during changing of tone color, a tone color

parameter specified for changing that has have been read out from the general-purpose storage means may be transferred into the cache memory. In this case, because the tone color parameter group comprising a freely chosen number of tone color parameters has been registered in the general-purpose storage means, the need to transfer a tone color parameter from a system control section to the general-purpose storage means each time a tone color is to be changed can be removed as much as possible. Moreover, because the output bit width of the cache memory has been made to be large, the tone color parameter can be set into the tone generator means instantaneously. Consequently, even though the tone color parameters are stored in advance in the general-purpose storage means, the time taken for the tone color changing process can be shortened, and hence the occurrence of a break in sound generation during tone color changing can be prevented.

Further, the tone color changing process is carried out by system control means sending the leading address for the tone color parameter to be changed to in the general-purpose storage means, and hence the amount of data transfer between the system control means and the musical tone reproducing apparatus can be reduced.

[Brief Description of the Drawings]

[FIG. 1]

FIG. 1 is a diagram showing an example of the construction of a preferred embodiment in which a portable terminal apparatus of the present invention accommodating a musical tone reproducing apparatus of the present invention, is applied to a mobile phone.

[FIG. 2]

FIG. 2 is a diagram of an example of the construction of a musical tone reproducing apparatus of

an embodiment of the present invention.

[FIG. 3]

FIG. 3 is a diagram showing the detailed construction of a tone generator memory, a controller, and a cache memory in a tone generator hardware section of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 4]

FIG. 4 is a diagram showing an example of the data structure of a tone color parameter group registered in a tone generator RAM of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 5]

FIG. 5 is a diagram showing an example of the data structure of tone color parameters stored in a tone color cache memory of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 6]

FIG. 6 is a flowchart of a reproduction process carried out by the tone generator hardware section of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 7]

FIG. 7 is a flowchart of a tone color parameter memory registration process of a reproduction process carried out by the tone generator hardware section of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 8]

FIG. 8 is a flowchart of a tone color changing process of a reproduction process carried out by the tone generator hardware section of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 9]

FIG. 9 is a flowchart of a tone data process of step of a tone color changing process of a reproduction process carried out by the tone generator hardware section of a musical tone reproducing apparatus according to an embodiment of the present invention.

[FIG. 10]

FIG. 10 is a diagram showing an example of the construction of a conventional musical tone reproducing apparatus.

[Description of Reference Numerals]

1 mobile phone, 2 base station, 10 CPU, 11 RAM, 12 ROM, 13 communication section, 14 speech processing section, 15 tone generator hardware section, 16 I/F, 17 input section, 18 display section, 19 vibrator, 20 external apparatus, 21 microphone, 22 incoming speech speaker, 23 incoming call speaker, 24 bus, 25 antenna, 30 tone generator memory, 30a tone generator RAM, 30b tone generator ROM, 30c selector, 31 control section, 31a tone generator memory address generating circuit, 31b register address generating circuit, 31c control register, 31d Voice Adr change detecting circuit, 31e cache transfer waiting queue register, 31f slot number - voice address converting circuit, 31g key on masking circuit, 32 cache memory, 32a tone color cache memory, 32b cache address generating circuit, 33 tone generation core, 34 speaker, 110 CPU, 111 RAM, 115 tone generator hardware section, 130 tone color parameter storage region, 133 data processing section, 134 speaker